Process optimization in hospitals

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Personal experience

Advisor in VU medical center (0.25 fte)
- rapid diagnosis (Sonja Z, Berthe v G)
- sojourn times emergencies (Annemieke v D)

Trainings
- LogiZ
- eHealth

Research
- appointment scheduling (Guido K & Paulien O)
- bed assignments (Arnoud de B & René B)

Logistics and health care

- “Classical” logistics: drugs, supplies, bed linnen, …
- Patient logistics: primary care process
  - Service: patient is part of the process
  - General consensus: health care system is where manufacturing was in the 70s
  - Much to win!
- Cure ahead of care

Current trend: lean

- Focus on what adds value
- Remove sources of waste: inventory, batch processing, transportation, …
- Emerging: eHealth

Diversity in health care

- Doctors: every patient is unique
- ⇒ad hoc solutions
- However:
  – Homogeneous groups
  – Heterogeneous rest
- Popular before lean: focused factories
  – For homogeneous groups
  – For example: cataract, breast cancer
  – How about the rest?

Randomness

- Treatments times, patient path
- External/unavoidable vs. Internal/avoidable
  - Emergencies according to Poisson process; planned surgery equally variable!
  - Operations running late: due to complications but also morning traffic (and are all complications really unavoidable?)

Operations management

What needs to change urgently:

- daily management of health process
- patient orientation
- long-term implementation of changes (“borging”)

Less urgent:

- advanced planning systems

Case 1: Clinical ward

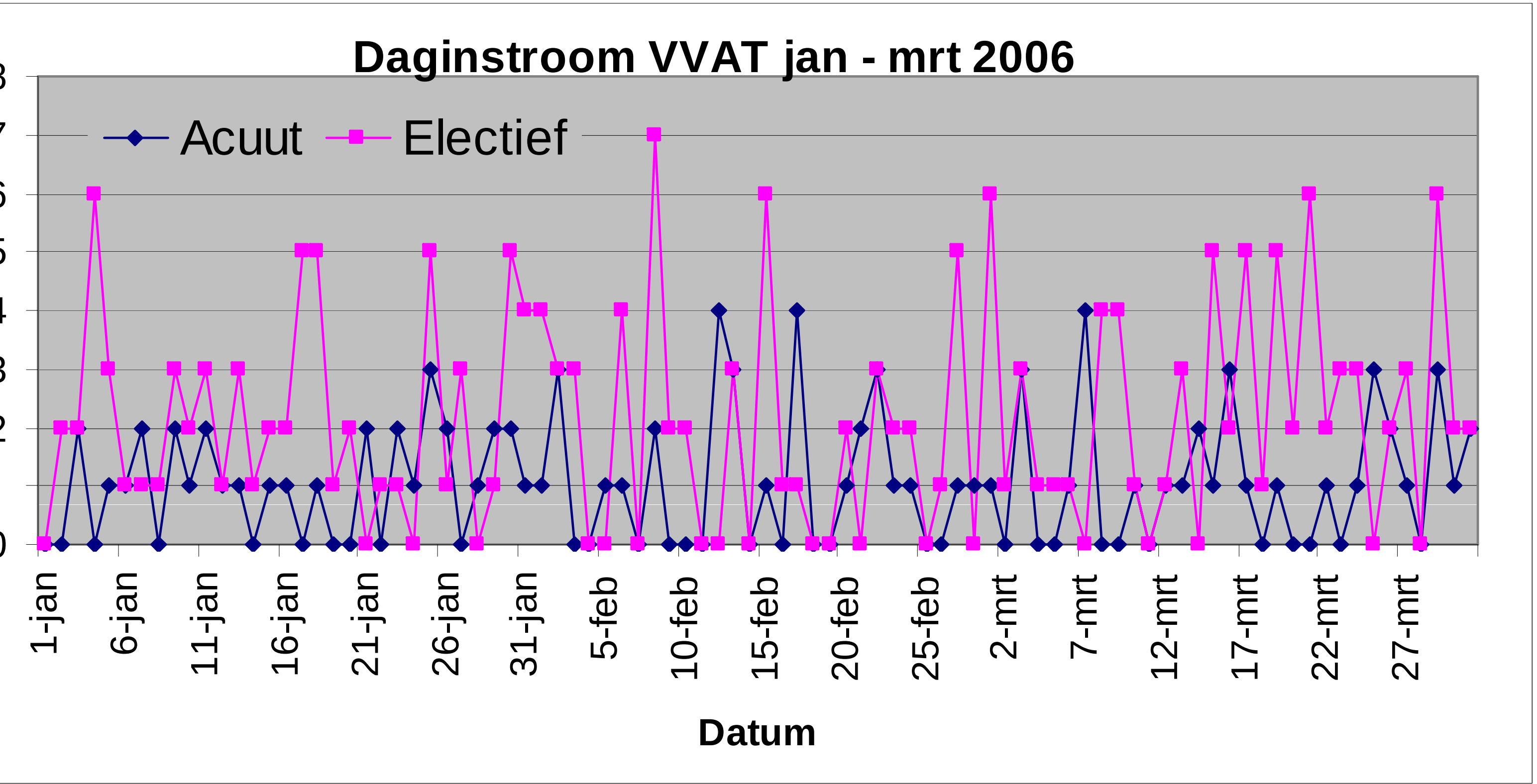
- Arrivals
- Admissions
- Length of stay (LOS)
- Number of operational beds

erformance:

- Bed occupancy
- refused admissions

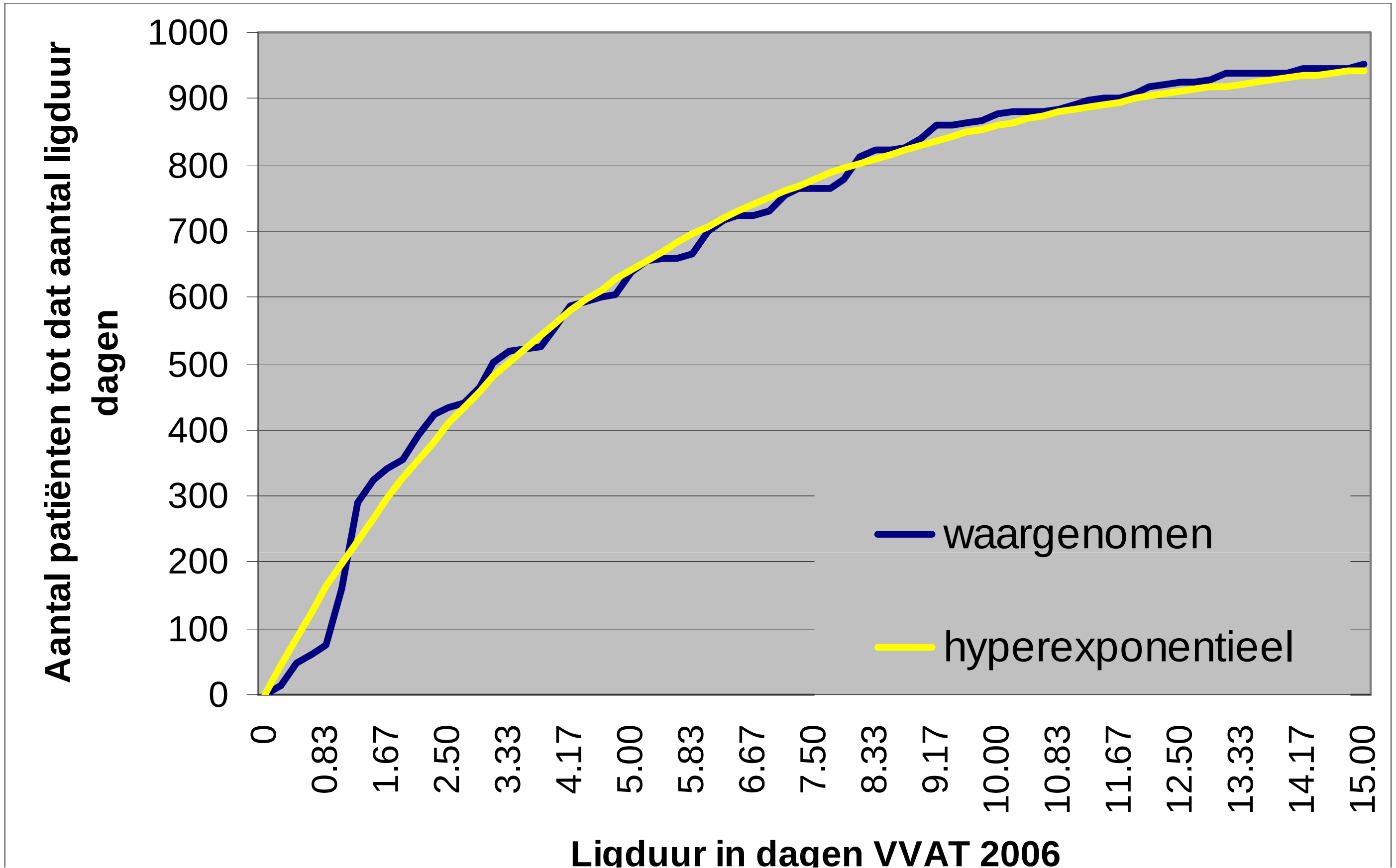
Data analysis

Admissions per day



Data analysis

LOS: hyperexponential distribution



Models

- Questions:
  - how to assign beds to specialties?
  - how many beds to take
    = how to distribute beds between specialties?
- Models required to evaluate changes
  - simplest model: Erlang B
  - validated at VUmc

How to assign beds?

conomies of scale

B(s,sa) decreasing in s = ec. of scale

Proof: Smith & Whitt 81, analytical properties of B(.,.)

B(s,sa) convex?

Diminishing returns

No proof, numerical evidence

Merging

Theorem:

$$+ \lambda_2\beta_2)B(s_1 + s_2, \lambda_1\beta_1 + \lambda_2\beta_2) \leq \lambda_1\beta_1 B(s_1, \lambda_1\beta_1) + \lambda_2\beta_2 B(s_2, \lambda_2\beta_2)$$

Compares occupation

Proof by coupling, Smith & Whitt 81

Thus: merging wards leads to higher occupancy

Merge all wards in case fixed revenue per night

Equal ALOS

$$\lambda_2)B(s_1 + s_2, (\lambda_1 + \lambda_2)\beta) \leq \lambda_1 B(s_1, \lambda_1\beta) + \lambda_2 B(s_2, \lambda_2\beta)$$

Thus merging minimizes overall blocking rate in case equal ALOS

Also if ALOS unequal?

And how about rates per ward?

Unequal ALOS

	ward 1	ward 2	weighted average	merged ward
arrival rate (λ)	1.00	5.00		6.00
ALOS (β)	5.00	1.00		1.67
# of beds (s)	3	7		10
ection % ($B(s,a)$)	53%	12%	19%	21%
cupancy % ($\mathbb{E}L/s$)	78%	63%	67%	79%

Merged ward has higher blocking prob.

Unrealistic numbers

Per ward, equal ALOS

ICU	a	s	B(s,a)	Weighted av.
1	20	20	0.16	0.13
2	8	12	0.05	
merged	28	32	0.07	

But blocking % type 2 increases

Overall blocking % decreases

Ward scheduling

How to take advantage of scale…

while satisfying rejection constraints?

Answer: dynamic bed assignment

Dynamic policies

- Equal ALOS
  - DP formulation
  - Optimality of threshold policies
- Unequal ALOS
  - DP formulation
  - curse of dimensionality

Bed reservations

- ‘ear marking”
- single and multi-skilled nurses

Case 2: planning of shared resources

- Queueing at bottleneck resources
- Queueing = slot in schedule at later time
- Different types of patients
  - – different specialties/treatments
  - – urgency
- First: single-type queue

Waiting lists

How to reduce length of waiting lists?

Queueing model: Erlang C or M|G|c seems logical

Best practice

- ihi.org: Advanced access
- CBO: Werken zonder wachtlijst
- Use “lean”: improve process to decrease service times and arrival rate and make system stable
- Work away backlog
- After that: no more queues

“do today’s work today”

Practice

- Queues grow again!
- Reasons
  - short queues attract more patients
  - long queues make patients go elsewhere
- Could have known
  - queue lengths were stable
  - contradicts standard queueing models

Practice

Avoid more patients to enter

Restrict patient pool

‘panel size”

not always possible

een, Savin, & Murray, Providing Timely Access to Care: What is the Right Patient Panel Size?, Jt Comm J Qual Patient Safety, 2007

Shared resources

- Resources used by multiple types of patients
- Usually further in the chain
- Less sensible to changes in access time
- Typical example:
  - CT or MRI scan

Types of patients

- Not urgent: waiting time order of weeks
- Emergency: directly/same hour
  - E.g., trauma patient
- Urgent: same or next day
  - E.g., clinical patient
- Scheduling methodology: walk-in or slots
  - walk-in possible for short service times

Slots

urrent practice:

Every specialty has its own slots or block of slots

Empty slots are filled in few days in advance

sadvantages:

Time left beginning or end of blocks

No match demand and supply

Often empty slots

Solution method

alk-ins for urgent are feasible?

Yes: create walk-in blocks part of the day (on part of the scanners)

No: reserve slots for urgent patients

Model for slots

Crucial: Can empty slots still be filled?

Modeling slots

- Usual approximation: number of urgent patients per day is Poisson distributed
- When empty slots can still be filled:
  – take “enough” slots
- When empty slots cannot be filled:
  – risk of unoccupied slots
  – solution: merge slots of specialties
  – economies of scale

More advanced slot reservation systems

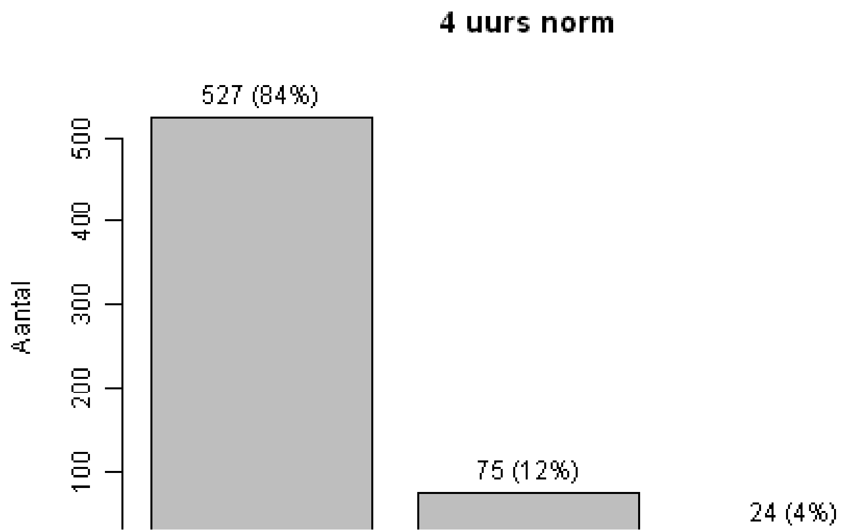
xample

- Slots can be given away day before
- Slots for same day or day after
- Reserve u_k slots day of the week k
- When more than v_k slots for day k at end k-1: give away until v_k
- Markov chain model

Case 3: sojourn times at ED

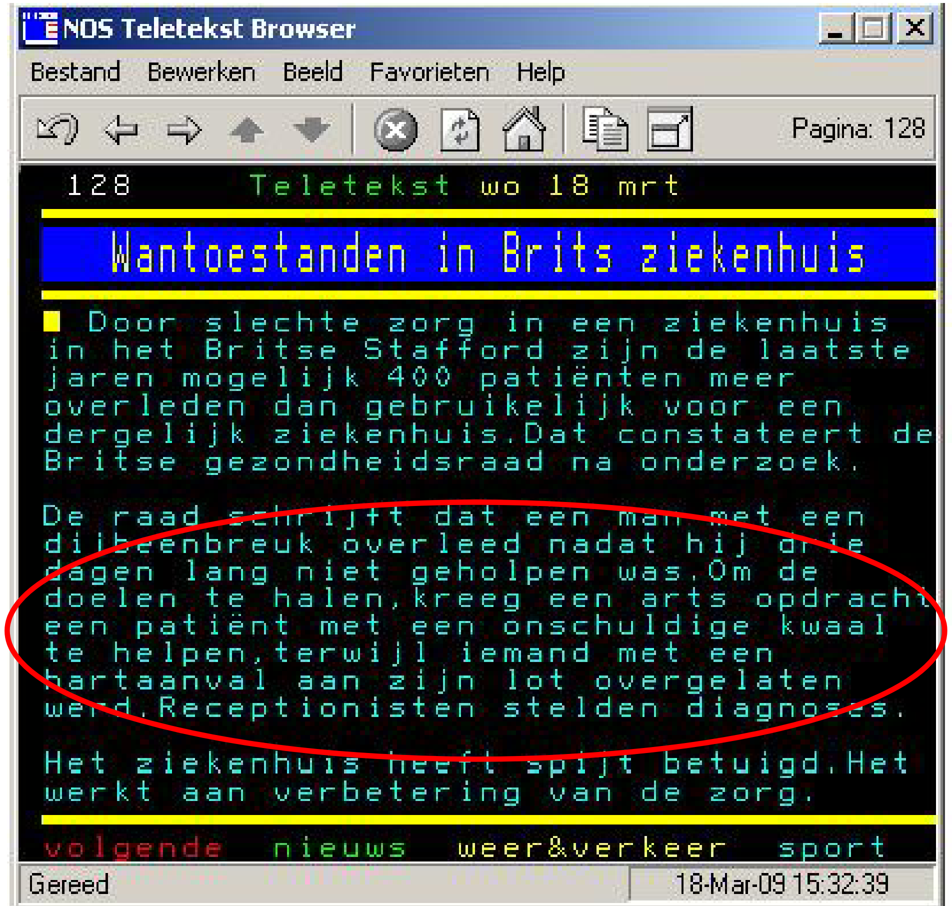
‘mess”: not clear where to start

data analysis on manually collected data

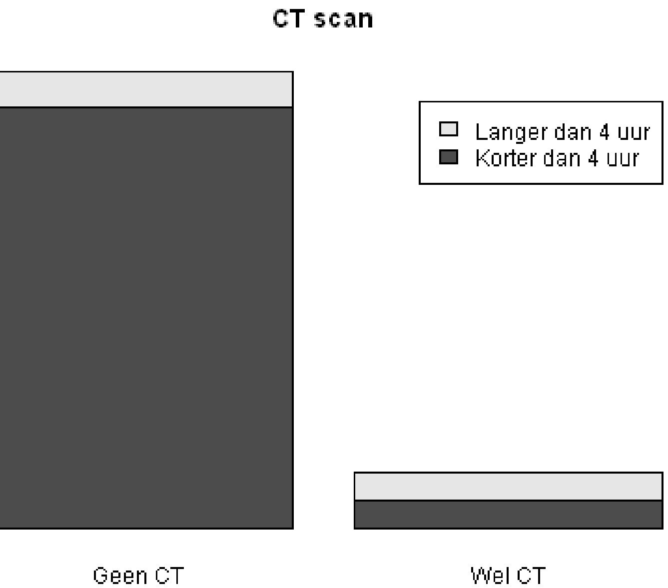


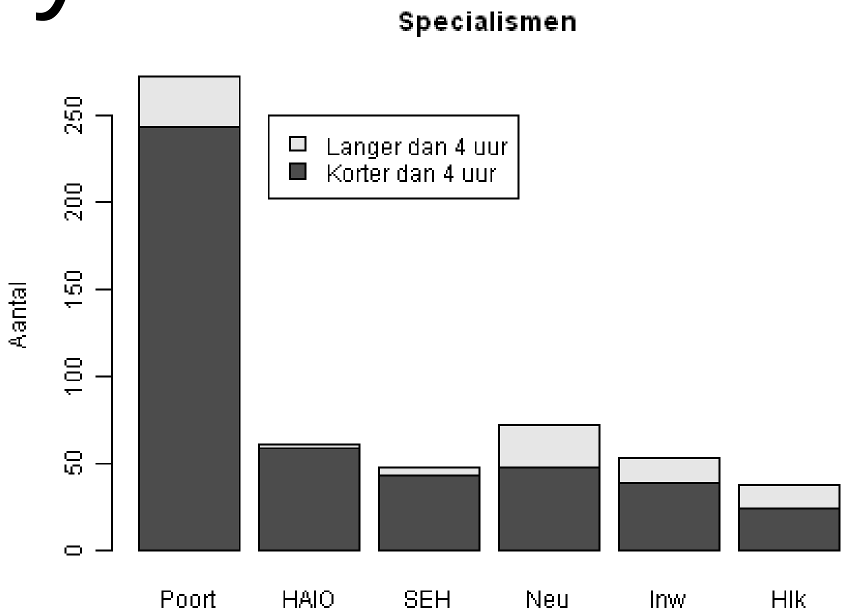
4-hour objective

- areful with steering on -hour norm
  - : Seddon, Systems thinking in e public sector
- n an attempt to meet he target four-hour &E waiting time, atients were ometimes "dumped" in ward without nursing are"
  - es Online



Data analysis at ED





Preliminary conclusions:

- radiology is not to blame
- no mgmt related to sojourn times
- corresponds to literature

Conclusion

- Health care interesting area for OR/OM
- Doctors are really interested in OM, not just in outcomes
- Cultural changes necessary
- Health care needs to change (budget cuts)